

Engineering and the Prevention of Global Chronic Disease: Forging Partnerships Between Engineers and Public Health Leaders

Sujata K. Bhatia^{1*} & Sandeep P. Kishore²

¹School of Engineering and Applied Sciences, Harvard University, Cambridge, MA; ²Department of Global Health and Social Medicine, Harvard Medical School, Cambridge, MA

*Address all correspondence to: Sujata K. Bhatia, Harvard University, School of Engineering and Applied Sciences, 206C Pierce Hall, 29 Oxford Street, Cambridge, MA 02138, e-mail: sbhatia@seas.harvard.edu

ABSTRACT: Non-communicable diseases (NCDs) are driven by factors that influence how we live, work, age, play and pray—which are themselves influenced by our environment, its design, and our communities. We argue that engineers possess a unique capability to improve health by alleviating the growing burden of NCDs. We discuss specific ways in which engineers can improve the natural environment, the built environment, the food system, and medical diagnostics. Further, we call on the university community to firmly animate and situate the role of the engineer in fighting for public health. Engineers have a duty to prioritize the public good. Engineers must now be empowered to view themselves as agents of public health.

KEY WORDS: global health; public health; non-communicable disease; environment

I. INTRODUCTION

A natural intersect exists between engineering and public health; both disciplines seek to build communities and improve quality of life. Engineers have a duty to prioritize public health and the public good. The Code of Ethics of the National Society of Professional Engineers states that “Engineers shall hold paramount the safety, health, and welfare of the public” as its first Fundamental Canon; the code also states that “Engineers shall at all times strive to serve the public interest” as the first Rule of Practice.¹ This value is echoed in the codes of ethics for professional engineering organizations in every major engineering discipline, including the American Society of Mechanical Engineers², the Institute of Electrical and Electronics Engineers³, the American Society of Civil Engineers⁴, the American Institute of Chemical Engineers⁵, and the Biomedical Engineering Society.⁶ Further, the Obligation of the Engineer, an oath taken by graduating engineers, confirms that “skill carries with it the obligation to serve humanity.”⁷ Public service is thus naturally and deeply embedded in the engineering ethos.

We argue that this power can be focused for public health in the 21st century. Specifically, we argue that engineers possess a unique capability to improve health by alleviating the growing burden of non-communicable diseases (NCDs). The risk factors for NCDs such as cardiovascular disease, hypertension, chronic respiratory disease,

cancer, and diabetes, are all man-made and include environmental toxins, poor nutrition, tobacco and physical inactivity. NCDs as a public health priority are notable in two respects. First, the prevalence is still greatly increasing and secondly, they affect the affect the rich and the poor, both between and within countries. Now, children as young as 8 years old possess fatty streaks in their arteries which presage even greater health losses and premature deaths in this century.⁸ The World Economic Forum suggests a \$47 trillion lost by 2030 and poses that NCDs are the world's third largest global risk (second to oil or credit crisis).⁹ NCDs are not be viewed as diseases unto themselves, but rather as indicators of a sick society, a society that engineers are well-equipped to help fix in this century.

II. A 21ST-CENTURY VISION OF HEALTH: HEALTH BEYOND HEALTH CARE

Populations in the United States gained 30 years of life expectancy in the past century. Notably, only an estimated 5 of the 30+ years gained in life expectancy were attributed to medical care.¹⁰ The gains were from public infrastructure in sanitation, and hygiene; this explains, in part, the heavy public health/hygiene focus in the past century. Engineering and public health is not a new synergy though the interactions of the fields declined particularly with the advent of modern biomedicine in the middle of the century. In the 21st century, we are faced with different but complementary challenges. Data from the United States suggest that inadequate access to health care represents only 10% of the determinants of premature mortality¹¹; behavioral determinants represent 40%, social determinants 15%, and environmental determinants 5%. It is often easy to forget that these risks are man-made and therefore amenable to man-made solutions. Furthermore, these risks are spreading globally and threaten the development of even the poorest countries. Non-communicable diseases (NCDs) are driven by factors that influence how we live, work, age, play and pray—which are themselves influenced by our environment, its design, and our communities.

III. A 21ST-CENTURY CHALLENGE FOR THE UNIVERSITY COMMUNITY

We believe that the synergy and exposure to public health by engineers (and vice versa) could be heavily influential in the mental models of the world's students and, in a generation, lead to a paradigm shift in how we approach (and promote) public health. Thus, the university community is a crucial lever to productively integrate the public and engineering into the mental models of the world's students. The university also provides a unique environment where students and faculty from diverse cultural and educational backgrounds can convene to exchange ideas. We call on the university community to firmly animate and situate the role of the engineer in fighting for public health. This moves the engineer beyond the realm of designing novel diagnostics and devices for health care to squarely re-imagining our environment and the design of our society.

IV. SO, HOW DO WE GET THERE? A GLOBAL TURNING POINT: 2011

The United Nations held a high-level meeting on NCDs with heads of state in September 2011. This extended beyond its health arm, the World Health Organization, as the world affirmed that tackling NCDs was a social and structural issue. This meeting involved various UN groups including the United Nations Environment Programme (UNEP), UNICEF, as well as non-governmental organizations. This was a watershed moment for health; it was only the second time the United Nations has met on a health issue (the first was on HIV/AIDS), and it provided the mandate to position health in much broader terms than health care. While many public health officials and leaders from all sectors, including academia, were present at this UN meeting, the voice of the engineering community was noticeably absent. However, we believe that this UN mandate provides a 21st-century window for re-thinking curricula and the pathways for engineering students.

From this mandate, four focus areas emerge for engineers: the natural environment, the built environment, the food system, and medical diagnostics.

1. **The Natural Environment:** Civil engineers and environmental engineers can develop improved wastewater treatment and remediation processes to remove environmental triggers of disease (e.g., arsenic). Chemical and biological engineers can additionally contribute to environmental cleanup efforts by developing microbial remediation processes. Indoor cooking stoves and pollution drive unnecessarily high rates of chronic lung disease, cutting short the lives of many, and engineers can contribute to solving these issues.
2. **The Built Environment:** Structural engineers could contribute to the design and planning of cities that encourage physical activity and could devise ways to ‘retrofit’ old cities to accommodate the modern changes in lifestyle and health.
3. **The Food System:** By 2050, the world will need to double its food supply to feed the 9 billion people on the planet. This poses a severe development challenge, as quality will likely be sacrificed for quantity; more and more unhealthy foods will be introduced into the population. Engineering solutions can help bring healthy foods from seed to table much more efficiently and cheaply, thereby increasing global accessibility to healthy foods.
4. **Health information:** Engineers can undoubtedly assist in the creation of novel tools to aid in the identification of individuals at risk of developing chronic disease early in life. Technology, and particularly information technology, electronic health records, and novel diagnostics, will be crucial to identify those at highest risk and provide palliation early.

V. TOWARD ENGINEERING FOR PUBLIC HEALTH: A CURRICULAR REVOLUTION

Currently, synergies between engineering and public health are usually ad-hoc, a virtue of historical accident rather than intention. This stems from the fact that public health and engineering are considered disparate disciplines. We propose that capstone design courses can be incorporated into all engineering curricula. In such courses, teams of engineering students collaborate with public health professionals to develop and implement a solution to a pressing health need. We provide several examples from universities in the United States because we are based in the United States, though these programs could certainly be spearheaded at any university in the world. A concrete example is the Stanford BioDesign program¹², which immerses engineering students in health settings. Stanford offers a course titled “Global Biodesign: Medical Technology in an International Context.” The course includes students, postdoctoral fellows, and faculty from business, engineering, humanities and science, law and medicine. This example can (and should) extend beyond medical technology into the natural environment, the built environment, and the food system. Engineers Without Borders¹³, founded in 2002, is an organization that completes small-scale development and infrastructure projects in 45 developing countries. It includes professionals and students from public health, engineering, anthropology, and business; projects include sanitation and wastewater treatment, providing perfect conduits to train and deploy students. Engineering World Health¹⁴, founded in 2001, sends teams of mechanical, electrical, and biomedical engineers to resource-poor settings to identify medical technology needs as well as repair existing medical devices. The Engineering for Developing Communities (EDC) program at the University of Colorado-Boulder¹⁵, which educates globally responsible engineering students who can offer sustainable, appropriate technology solutions to the endemic problems of developing communities, provides an example of the early trends that can be taken to scale soon.

At our university (Harvard), we believe it is possible to establish public health engineering courses that engage students from engineering, medicine, business, and law to work in inter-disciplinary teams. In the next 25 years, it is feasible that more inter-disciplinary degree programs in “Engineering for Public Health” will be created at both the undergraduate and graduate level. Moreover, engineering courses can be offered at medical schools and public health schools, so that healthcare professionals and public health advocates can gain an appreciation for the possibilities enabled by engineering. The World Health Organization targets for the prevention and control of NCDs¹⁶ can provide specific societal, cross-disciplinary goals for engineers to achieve. Engineers must be empowered to view themselves as agents of public health.

As engineers (particularly in sanitation and nutrition) helped unlock health gains in the 20th century (the largest increase in life expectancy in mankind’s history) by focusing on the natural environment, we wonder if engineers can re-imagine and apply their training to tackle the man-made issues attendant to the built environment, the food system, and health information in addition to the natural environment. The po-

tential for synergy between public health and engineering in a century where children may not live as long as their parents (where life expectancy has stalled and will even decline, as in Russia, and potentially the United States) has never been greater. Public health benefits from engineering efforts, and engineers benefit from working in public health. Such work teaches engineers to incorporate human needs into engineering designs, and encourages engineers to consider cultural, societal, and structural factors in novel designs. Engineers learn leadership, communication, creativity, and commitment from work in public health; such skills equip engineers to make substantial contributions in any field. Students and faculty can work together now to intentionally situate public health and engineering early in training. The co-benefits for both disciplines are sizeable, and the potential benefit to society at large is transformative. But who will step up?

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